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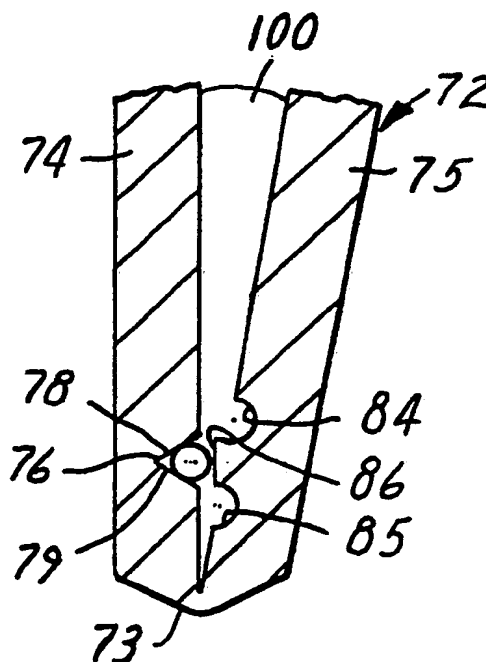
(11) Publication number:

0 431 768 A1

(12)

EUROPEAN PATENT APPLICATION(21) Application number: **90312394.1**(51) Int. Cl.⁵: **G02B 6/38**(22) Date of filing: **13.11.90**(30) Priority: **15.11.89 US 437027**(43) Date of publication of application:
12.06.91 Bulletin 91/24(84) Designated Contracting States:
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W-8000 München 2(DE)**(54) **Stamped precision lightguide interconnect centering element.**

(57) Elements for making butt splices, in optical fibers, formed of a permanently deformable material, e.g. metal or polymeric material, can be formed to define three surfaces 78, 79, and 86 for contacting the fibers to be spliced. The surfaces are formed between two legs 74 and 75 of an element such that when the legs are closed onto the fibers, the surfaces center the fibers by embedding the fibers into the surfaces and afford a resilient spring compression reserve force on the aligned fibers to maintain them in contact and clamp the fibers in the element.

**FIG. 5****EP 0 431 768 A1**

STAMPED PRECISION LIGHTGUIDE INTERCONNECT CENTERING ELEMENT

This invention relates to optical fiber splicing elements and in one aspect to an improved optical fiber centering and holding device to afford the splicing of and alignment of ends of optical fibers.

The art is becoming replete with devices for centering optical fibers for the purpose of aligning ends of optical fibers for splicing the ends of fibers for continued transmission of light rays along the fibers. The optical fiber used in the telecommunications industry is mostly a single mode glass fiber. This fiber typically contains a $8\text{ }\mu\text{m} \pm 1\text{ }\mu\text{m}$ diameter central glass core through which the optical signal is transmitted. The core is surrounded by a glass cladding which has a diameter of $125\text{ }\mu\text{m} \pm 3\text{ }\mu\text{m}$. The cladding has a slightly different index of refraction than the core.

There are a number of prior art devices which have been designed to make permanent connections or splices in single mode glass fiber. To function properly and produce a low loss splice, these devices must align the core portions of the two fiber ends being spliced to within approximately 10% of their core diameter or less than $1\text{ }\mu\text{m}$.

Some of the prior art devices attempt to achieve fiber end centering and alignment by forcing the fibers into a non-conformable "V" groove or between non-conformable rods. These devices function satisfactorily as long as the fibers being spliced are the same diameter. Examples of such devices are disclosed in U.S.A. Letters Patent No. 4,029,390; 4,274,708; and 4,729,619.

When the fibers to be spliced have diameters at opposite ends of the tolerance range ($122\text{ }\mu\text{m}$ and $128\text{ }\mu\text{m}$), the non-conformable "V" groove type devices have difficulty providing the required core alignment precision.

Other prior art devices urge the two fiber center lines into alignment with one another by locating the fiber ends between three equally spaced ductile or elastomeric surfaces. These surfaces create an equilateral triangular cross-sectional channel into which the fibers are positioned. The junction between the fiber ends is located usually at the mid point of the channel. These devices provide better performance than the non-conformable "V" groove type devices because they are better able to accommodate differences in fiber diameters. Examples of these devices are found in U.S.A. Letters Patent Nos. 4,391,487; 4,435,038; and 4,593,971.

Another prior art patent is U.S.A. Letters Patent No. 4,339,172 which utilizes a foldable grip member that is placed within an elastomeric sleeve which affords compressive forces against the grip

member to assert pressure on the grip member to grip each of the cables at a number of equally-spaced points around its periphery.

The device of the present invention utilizes three contact surfaces which form a fiber centering channel as do other prior art devices, but the device contains easily definable functional and performance improvements over the prior art. These differences in structure and means of operation are discussed below.

The splicing element of the present invention provides three high precision fiber contact surfaces and at least one of the surfaces is movable in relationship to the others on an integral actuation structure affording such movement in a single easy to manufacture part. The fiber clamping surfaces are initially spaced apart to allow fibers to be easily inserted into a progressively narrowing channel or passageway until the end faces are in contact. This structure makes it easy to detect by tactile feedback and/or buckling in the opposing fiber when the first fiber is pushed against the opposing fiber in the passageway. When the fiber ends are in contact, the splice element is closed and the fiber ends are aligned and clamped.

The prior art, such as the device of U.S.A. Letter Patent No. 4,391,487 and the commercial form sold by the assignee of U.S.A. Letters Patent No. 4,391,487, utilizes molded elastomer blocks for centering and aligning the fiber. These blocks contain an essentially triangular cross-sectional passageway which is slightly smaller than the diameter of the fibers. When the fibers are inserted into the molded passageway, they are required to force the elastomer surfaces open by elastically deforming the elastomer contact surfaces. This requires significant compressive force on the fiber to push it into the passageway. Because of this high insertion force, it is often difficult to tell when the fiber end faces are actually in contact inside the splice. Additionally, it is possible to break the fibers under compressive buckling as they are forced into the elastomeric centering blocks.

Only very small ductile or elastic deformation of the fiber locating surfaces is required in the splice element of the present invention to provide precise fiber centering and clamping. This deformation creates no external material flow parallel to the axis of the fiber and produces no ductile deformation of the hinged structure around the clamping surfaces. Other prior art devices such as the connector of patent No. 4,435,038 require extremely large deformations of the fiber clamp surfaces and surrounding structure to produce fiber centering and clamping. Unfortunately, these large de-

formations may result in unwanted distortion of and unequal clamp forces on the fiber engaging surfaces. This in turn may also produce shifting of the fiber center lines and axial separation of the fiber end faces.

Forces high enough to embed the fiber uniformly into each of the clamping surfaces of the splicing element of the present invention by ductile deformation can be generated easily through the hinged lever structure afforded by the legs of the splicing element. Once clamped, the splicing element maintains uniform compressive loads on the fibers which result in high fiber tensile load retention, and excellent thermal cycling stability. The fiber clamp forces are maintained by elastic energy stored in the legs of the splicing element as well as in the clamping structure. Other prior art devices such as the connector of U.S.A. Letters Patent No. 4,435,038 tend to relax or elastically recover slightly after removal of the splice crimping tool forces. This relaxation may result in a slight loosening of the fiber in the locating channel which can lead to reduced pull out forces as well as fiber end face separation during thermal cycling.

During the fiber centering and splicing process in the splicing element of the present invention, clamping loads are generated on the fiber. Since glass has very high compressive strength, these loads tend to embed the fibers into the three ductile contact surfaces forming the fiber channel in the element. These clamping loads on the fiber cladding result in excellent tensile load retention capabilities and thermal cycling stability for the splice. In addition, the application of the clamping load is easily and quickly accomplished simply by squeezing together the legs of the splice element. Other prior art devices such as the fiber centering device of U.S.A. Letters Patent No. 4,391,487 require adhesives to bond the fiber to the external splice structure beyond the fiber centering blocks. These adhesives can be difficult and time consuming to apply and to cure uniformly.

The splicing element of the present invention has also been designed to permit reopening and release of the fiber ends. If it becomes necessary to reposition fibers within the splice, the clamping force provided on the legs of the element can be easily removed, and the elastic memory in the element legs and hinge sections will cause the fiber locating and clamping surfaces to move apart. The clamping loads on the fibers are then released, and the fibers can be repositioned. Other prior art devices such as the connectors of U.S.A. Letters Patent Nos. 4,391,487 and 4,435,038 are permanently crimped or adhesively bonded and cannot be reopened.

The present invention provides a deformable splice element for use in butt splicing two optical

fibers which generally have different diameters due to manufacturing tolerances. The element is formed of ductile material and comprises means defining three generally planar fiber supporting surfaces disposed with each surface positioned at an acute angle to a second surface and defining an optical fiber passageway therebetween adapted to receive two fiber ends in abutting relationship to be spliced together. The passageway has a generally triangular cross-section formed by three angularly related fiber supporting planar surfaces. One surface is defined on one supporting structure for movement in relationship to the other fiber supporting surfaces to draw one of said supporting surfaces toward the other two of the surfaces with sufficient force to engage two fiber ends and cause each of the fiber supporting surfaces to deform uniformly around the fibers adjacent their ends with the larger of the fiber ends being embedded uniformly into each of the three fiber supporting surfaces to a slightly greater depth than the smaller diameter fiber. Thus, the variations in fiber diameter due to manufacturing tolerances are accommodated and the result is the two fiber ends are brought into coaxial alignment and the fiber ends are clamped with sufficient compressive force to restrict the fiber ends from separating, unless an unusual amount of force is applied to the fibers, and insufficient force to be deleterious to the ends of the optical fibers.

In the present invention, two of the three fiber supporting surfaces are formed on one plate-like member of the element and the third fiber supporting surface is formed on a second plate-like member which is movable about a fold to press the fiber ends into the two surfaces on the other plate-like member. The plate-like members are like legs and the fiber support surfaces form the alignment passage.

The splice element is formed of an integral piece of deformable material to result in a small sheet, examples of such material being metals or polymeric material, having sufficient elastic yield strength to apply the clamping forces on the fiber ends.

The present invention will be further described with reference to the accompanying drawing, wherein:

Figure 1 is a plan view of a sheet forming the splice element;

Figure 2 is an end view of the sheet of Figure 1; Figure 3 is a side view of a splice element formed from the sheet of Figure 1;

Figure 4 is an end view of a completed splice formed of the sheet of Figure 1;

Figure 5 is an enlarged fragmentary cross sectional view of the splice element of Figure 3 before closing on an optical fiber; and

Figure 6 is an enlarged fragmentary cross sec-

tion of a second embodiment of the splice element having aligning surfaces corresponding to the element of Figures 1 to 5 with legs of equal length and shaped to be urged together by a cap.

The present invention will be described with reference to the accompanying drawing wherein Figures 1 through 6 illustrate the splice element generally designated 70 which comprises a sheet 72 of ductile, deformable, elastic material.

Figure 1 illustrates an embodiment of a sheet forming a splice element 70. In Figure 1 the sheet 72 is formed with a definite profile. Sheet 72 has a portion of reduced thickness, formed by a groove 73, which extends generally the length of the sheet 72. This groove separates the sheet into a first plate-like member or leg 74 and a second plate-like member or leg 75. The groove 73 forms a fold line along which the sheet 72 is folded to afford relative movement of the legs 74 and 75 to bring the legs toward one another. The plate-like leg 74 has a single V groove 76 running lengthwise of the sheet, which V groove is formed with two angularly positioned generally planar fiber supporting surfaces 78 and 79, see Figure 5. The V groove 76 has ends and at the ends adjacent the ends of the sheet 72 are concave recesses 80 and 81, respectively which are joined to conical surfaces. The V groove 76 is positioned parallel to the groove 73 and closer to the groove 73 than the edge 82.

The plate-like leg 75 is joined to the plate-like leg 74 along the fold line formed by groove 73. The leg 74, as illustrated, has a pair of spaced concave parallel recesses 84 and 85, see Figure 5, extending lengthwise thereof and the surface 86 therebetween defines the third of three fiber supporting surfaces of an optical fiber passageway into which the ends of the fibers to be joined are positioned. The leg 75 has an edge 88 spaced from the fold line 73, which edge is not spaced as great a distance as the edge 82 to permit the edge 82 to be folded over the edge 88 as will be explained below. The edge 88 is joined to the sheet 72 at the groove 73 by end walls. Also connected to the sheet 72 at the groove 73, are wings 90 and 91. The wings 90 and 91 extend away from the portion 73 of reduced thickness, one adjacent each end wall of the leg 75. The wings 90 and 91 are formed with recesses 94 and 95, which are aligned with the third fiber supporting surface 86. The recesses 94 and 95 cooperate with the concave recesses 80 and 81, and the conical surfaces to define funnel-shaped fiber guiding openings for directing the fiber ends to the fiber receiving passageway defined by the surfaces 78, 79 and 86, when the first and second plate-like legs 74 and 75 are folded to form said fiber receiving passageway. The funnel-shaped openings and the

slight crown along the length of the surfaces 78, 79 and 86 guide the fiber ends into the passageway and position them to be properly aligned when the element is closed.

The sheet 72 is preferably formed of a metal, such as an aluminum, from a sheet of 0.5 mm (0.020 inch) thick alloy 3003 with a temper of 0. The hardness of the material can be between 23 and 32 on the Brinell scale (BHN) and the tensile yield strength can be between 35 to 115 MPa (Mega pascals) (5 to 17 ksi). Another aluminum alloy is 1100 with a temper of 0, H14 or H15, together with a tensile yield strength and a hardness within the ranges. Both alloys provide a material which is much softer than the glass of the optical fiber and the cladding, but ductile under the clamping pressures applied to the optical fibers. Such deformation is sufficient that the surfaces 78, 79 and 86 conform to the optical fibers contacted and should one fiber be larger than another, the surfaces 78, 79 and 86 will deform sufficiently to clamp onto both fiber ends and be deformed even by the smallest of the two fibers. Thus, the splice element 70 will center the cores of the optical fibers such that, in aligned position, 90% or better of the surfaces of the core portions of the fiber ends will be aligned. The material of the sheet 72 is also resilient such that the elastic limit of the material in the hinge areas and lever means afforded by the side portions is not exceeded when the side portions are folded to contact and clamp a fiber therein. The elasticity of the material is such that the legs 74 and 75 will maintain a compressive force on the optical fiber after the splice is made to restrict the fibers from pulling out or the centers of the fibers from shifting from their position of alignment with each other. This continued spring compression also restricts any changes in the performance of the splice with changes in temperature. The reserve forces of this spring compression are always present when the splice has been completed.

The fiber ends are retained in the element such that the pull-out force will exceed the tensile strength of the glass fiber.

Other metals and metal alloys, or laminates thereof are useable to construct the sheet 72. Such metals include copper, tin, zinc, lead and alloys thereof. To have a clear splicing element, polymeric materials can be used and materials which are suitable include thermal forming grade polyethyleneterephthalate (PET) materials, e.g. film. A presently preferred film is a polyethyleneterephthalate glycol (PETG) film of about 0.5 mm (0.020 inch) thick. The material should have an elastic or tensile yield strength of between 21 to 115 MPa (3 to 17 ksi) and a hardness of between 13 and 32 on the Brinell scale to provide an element which is

satisfactory to align the fiber ends and clamp the ends to restrict separation.

The splice element normally has a gel 100 disposed in the area of the fiber receiving passageway, which gel has index of refraction matching characteristics similar to the fiber core to improve the continuity of the transmission through the splice.

As shown in Figures 3 and 4, the sheet 72 is folded along the reduced portion defined by the groove 73, to bring the legs 74 and 75 to the position as illustrated in Figure 5. The wings 90 and 91 are also folded flat against the leg 74 and the concave recesses 80 and 81, together with the recesses 94 and 95, form openings as illustrated in Figure 4 into which the fiber ends can be directed to guide them into the fiber receiving passageway between the legs 74 and 75. The fiber ends are inserted into the passageway formed by the surfaces 78, 79 and 86. The index matching gel 100 is placed in the passageway. The legs 74 and 75 are then moved together to tightly clamp the fibers and embed the ends of the fibers into the fiber supporting surfaces generally as illustrated in Figure 6. This occurs when the top edge of the leg 74 is closed over the edge 88 of the leg 75 to hold the legs in clamping position on the fiber ends maintaining them in axially aligned position. The deformable material of the element permits the element to be reopened to separate the fiber ends.

Figure 6 also illustrates a modified element having legs 120 and 121, which have generally the same length. The upper ends of legs 120 and 121 are rounded to define an arcuate outer edge. The legs 120 and 121 are thus shaped to receive an external cap member which can force the legs toward one another to clamp the fiber ends. Such an element can have a profile to fit in a splice element constructed according to U.S.A. Patent No. 4,818,055, wherein the splice element is seated in a base, corresponding to base 41, and the legs 120 and 121 can be forced together in fiber aligning position by a cap corresponding to the cap 60 illustrated therein.

The V groove 76 in the leg 74 or in leg 120 has the surfaces 78 and 79 disposed at generally 60° to each other. The elements 120 and 121 are formed of the materials described above.

Claims

1. A splice element for use in splicing two abutting ends of optical fibers which generally have different diameters due to manufacturing tolerances, said element being formed from a ductile material and comprising means defining three generally planar fiber supporting surfaces disposed with each surface positioned at an acute angle to a second

surface and defining an optical fiber passageway therebetween adapted to receive therein two fiber ends in abutting relationship to be spliced together, said passageway having a generally triangular cross-section and said element having first means for supporting a pair of said fiber supporting surfaces in angular relationship to each other, and second means for supporting the third of said fiber supporting surfaces for movement in relationship to the other fiber supporting surfaces to draw said third fiber supporting surface toward said pair of fiber supporting surfaces with sufficient force to engage two fiber ends and cause each said fiber supporting surface to deform uniformly around said fiber ends with a larger of said fiber ends being embedded into each of said three fiber supporting surfaces forming said fiber passageway to a slightly greater depth than said smaller diameter fiber to accommodate said variations in fiber diameter due to manufacturing tolerances but resulting in two said fiber ends being brought into coaxial alignment and for clamping said fiber ends with sufficient compressive force to restrict said fiber ends from being pulled out of said fiber alignment passageway and insufficient force to be deleterious to said optical fibers.

2. A splice element according to claim 1 wherein said first means and said second means are part of a single piece of material having a portion reduced in thickness between said pair of fiber supporting surfaces and said third fiber supporting surface to define a fold line affording the movement of said third fiber supporting surface in relationship to said pair of fiber supporting surfaces.

3. A splice element according to claim 2 wherein said first means comprises a first metal plate-like member having one edge defined by said portion of reduced thickness and a second edge spaced from said one edge, and wherein said second means comprises a second metal plate-like member having one edge defined by said portion of reduced thickness and a second edge spaced from said portion a distance less than said second edge of said first means, whereby said first plate-like member may be folded over the second edge of said second plate-like member to hold said third fiber supporting surface in close spaced fiber embedding and clamping position in relationship to said pair of fiber supporting surfaces of said first means.

4. A splice element according to claim 1 wherein said three generally planar fiber supporting surfaces each have opposite ends, and the ends of said pair of fiber supporting surfaces terminate in communication with concave recesses formed to guide the ends of fibers into said passageway and said third fiber supporting surface has the opposite ends thereof communicating with concave recesses

adjacent said ends.

5. A splice element according to claim 1 wherein said third fiber supporting surface has a groove formed parallel to and along each side thereof.

6. A splice element according to claim 3 wherein said second plate-like member has end walls joining said second edge and extending toward said portion of reduced thickness, and said metal piece has a pair of wings extending away from said portion of reduced thickness, one adjacent each end wall of said second plate-like member.

7. A splice element according to claim 1 wherein said three generally planar fiber supporting surfaces each have opposite ends, and the ends of said pair of fiber supporting surfaces terminate in communication with concave recesses formed to guide the ends of fibers into said passageway and said third fiber supporting surface has the opposite ends thereof communicating with convex surfaces adjacent said ends, and said wings are formed with recesses aligned with said third fiber supporting surface, which recesses cooperate with said concave recesses to form funnel-like openings to direct the ends of optical fibers into said passageway when said first and second plate-like members are folded to form said fiber receiving passageway.

8. A splice element according to claim 1, 2 or 3 wherein said ductile material is an aluminum alloy having an elastic yield strength of between 35 and 115 MPa.

9. A splice element according to claim 1, 2 or 3 wherein said ductile material has a tensile yield strength of between 21 and 115 MPa.

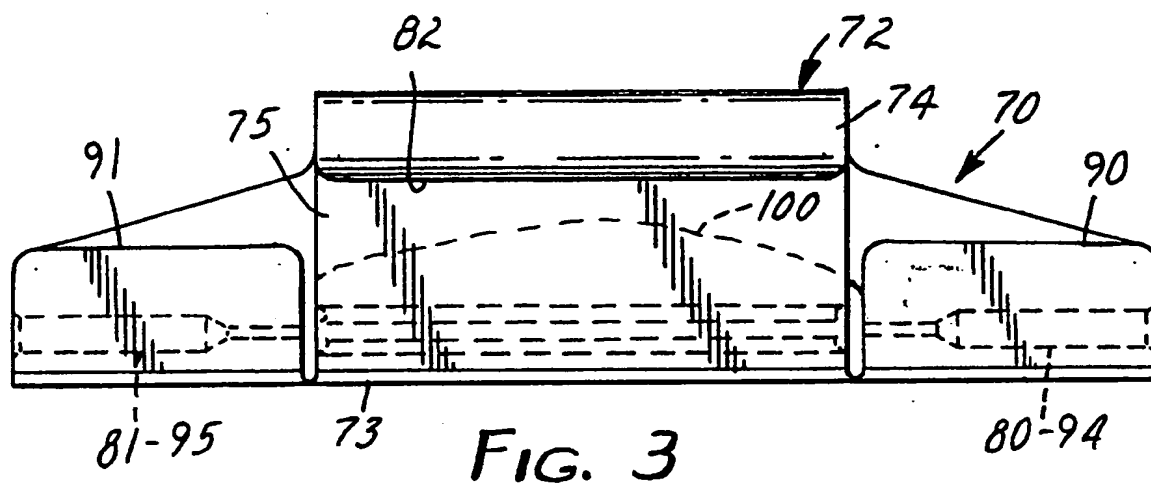
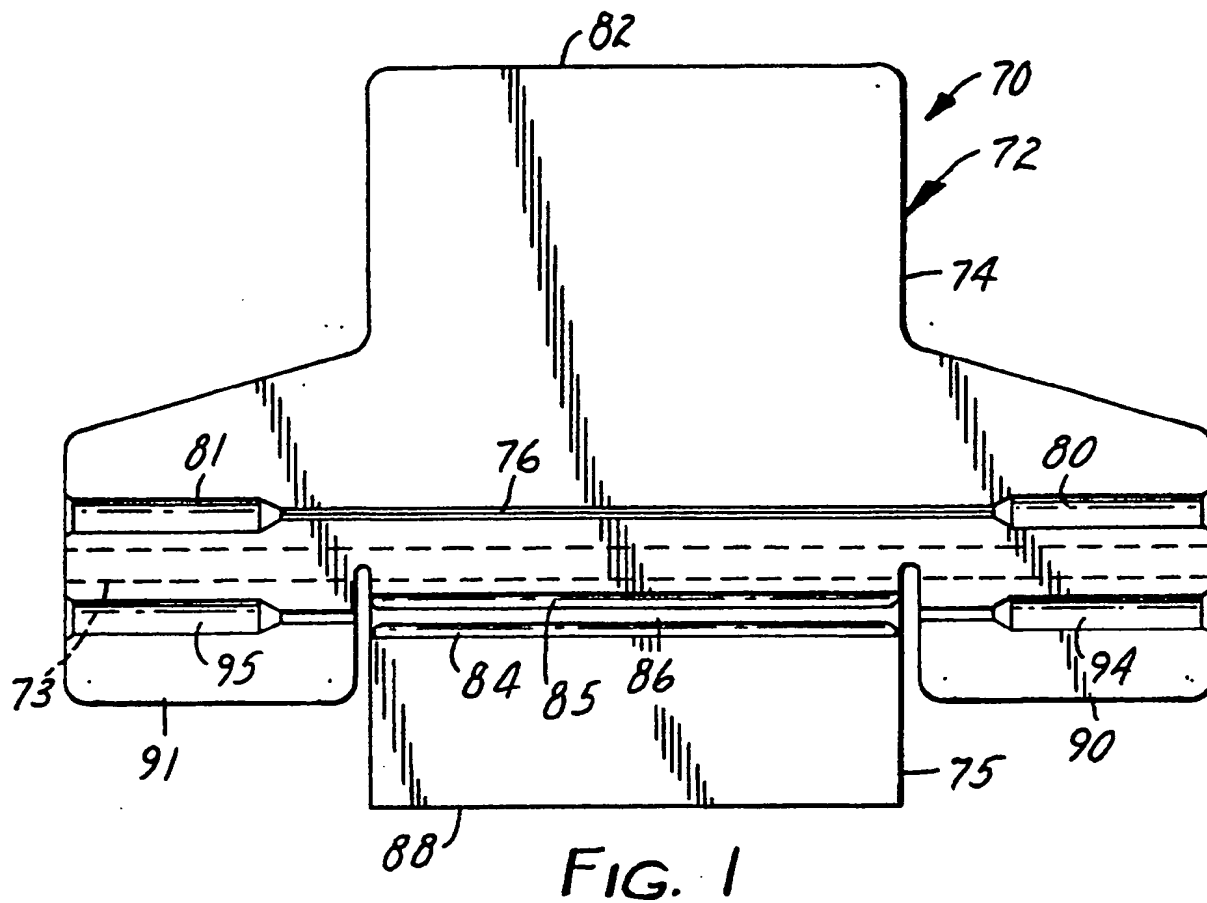
10. A splice element according to claim 1, 2 or 3 wherein said ductile material has a tensile yield strength of between 21 and 115 MPa and is a thermal forming grade polyethyleneterephthalate.

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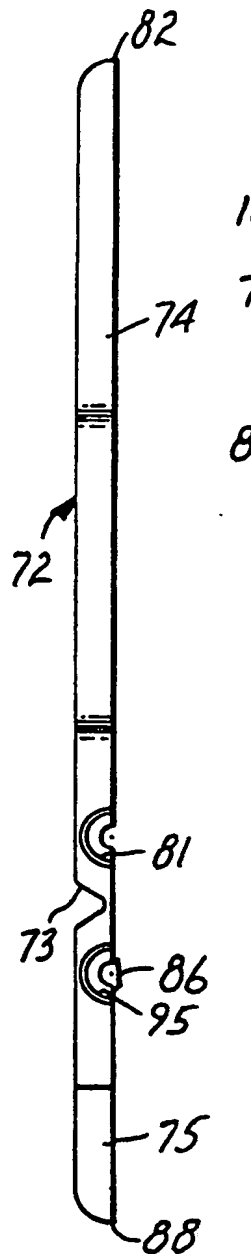


FIG. 2

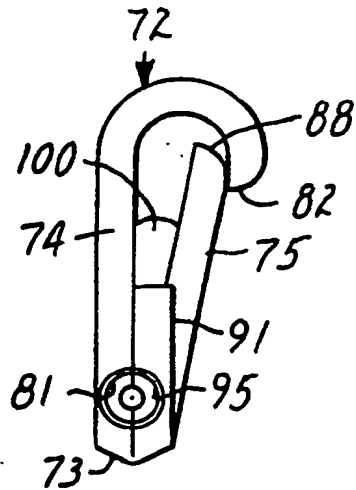


FIG. 4

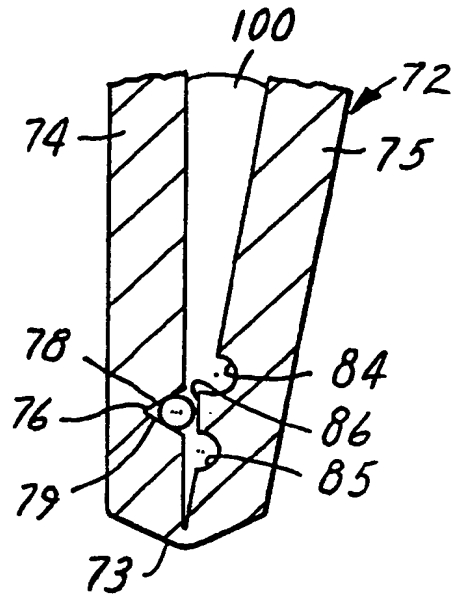


FIG. 5

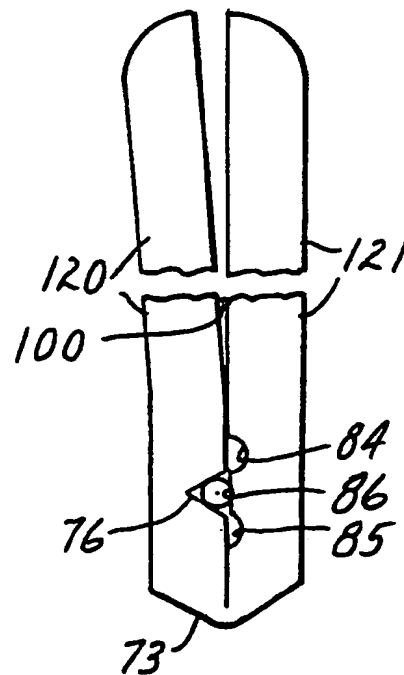


FIG. 6



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EUROPEAN SEARCH REPORT

Application Number

EP 90 31 2394

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)		
Y	EP-A-0 338 759 (MINNESOTA MINING AND MANUFACTURING) * Claims 1-8; figures 1-10 * - - - -	1-10	G 02 B 6/38		
Y	EP-A-0 290 188 (E.I. DU PONT DE NEMOURS) * Abstract; figures 1-9 * - - - -	1-10			
Y	EP-A-0 338 758 (MINNESOTA MINING AND MANUFACTURING) * Claims 1-9; figures 1-6 * - - - - -	1-10			
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)		
			G 02 B		
The present search report has been drawn up for all claims					
Place of search The Hague		Date of completion of search 12 March 91	Examiner MALIC K.		
<table border="0"><tr><td>CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention</td><td>EXPLANATION OF CITED DOCUMENTS E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons ----- &: member of the same patent family, corresponding document</td></tr></table>				CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention	EXPLANATION OF CITED DOCUMENTS E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons ----- &: member of the same patent family, corresponding document
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